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Sustainability and environmental management of pilgrimage tourism: A framework for mitigating environmental pressures at Mata Vaishno Devi Shrine

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ABSTRACT

Mata Vaishno Devi Shrine in Jammu and Kashmir is the best visited religious site in India with millions of pilgrims every year thronging this site. Although its religious and economic importance is beyond measure, the sheer number of pilgrimage tourism traffic has already presented a lot of environmental pressure on the location. Among the serious issues are challenges of waste production, water preservation, land degradation and quality of air. The research will look at the effects of pilgrimage tourism on the environment of the shrine environment and suggest a competency model of sustainable tourism growth towards introduction of technological advancements and community integration consideration. The study uses a qualitative method to examine both environmental tasks, the fieldwork, and the interviews conducted with the stakeholders. It singles out practices of proper waste management, water recycling, and energy efficiency such as the adoption of smart waste system, solar energy solution, and control with RFID features. The paper is applicable to the United Nations Sustainable Development Goals (SDGs), especially SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) and it can be used to provide a transferable construct on sustainable pilgrimage tourism. In the paper policy recommendations are offered that can come into place by the local authorities and they are mainly concerned with controlling the number of pilgrims, the management of waste products as well as fully capitalising on water and energy consumption. This study will make a contribution to the overall discussion regarding sustainable tourism practices in pilgrimage destinations by providing practical remedies to the reduction of any environmental impact without compromising on culture and spiritual heritage.

Keywords: Mata Vaishno Devi Shrine, pilgrimage tourism, sustainable tourism, environmental impact, waste management, water conservation, technological solutions, community involvement

INTRODUCTION

One of the most frequented places of worship in India after other places is the Mata Vaishno Devi Shrine which receives millions of pilgrims every year particularly in India and beyond. The shrine, located in the Trikuta Mountains of Jammu and Kashmir, is dedicated to the revered Hindu goddess Mata Vaishno Devi. It is also a great economic contributor as the religious tourism that the site attracts is of a large-scale. During the year 2019 alone, the shrine had more than 8.5 million pilgrims, and figures exceed these times during peak periods. It is difficult to commit the spiritual importance of the shrine to question, but the environmental pressures that come with such massive traffic of visitors have been vigorous. The problems of waste production, water resource saving, soil erosion, and air purification have been extremely problematic to local governments and environmentalists (Singh et al., 2021; Vukonić, 2002).

The issue of environmental degradation due to the sheer amount of pilgrims and tourists is among the major areas of concerns of the pilgrimage sites and especially the Mata Vaishno Devi Shrine. The amount of wastages generated by the daily pilgrimages is mind-blowing considering that there are so many many people who have visited the shrine leaving behind significant amounts of non-biodegradable wastes. Moreover, pilgrims have been increasing exponentially in the company, and there is a sudden increase in its water consumption, as the local water resources with residents fail to satisfy them (Singh, 2024). These environmental forces exerting on this sacred space demand swift response and integrated strategy which is expected to mobilise such a space to be sustainable and it should not compromise spiritual and cultural spaces values of such space.

Pilgrimage and all faith tourism bear significant cultural but also economic significance. But in either case, when it is not applied in a sustainable manner then this might lead to an irrecoverable devastation of the environment. Over the past years, the increased awareness of the necessity of sustainable tourism made the analysis of tourism resilience concepts and frameworks aimed at providing the balance between environmental conservation and preserving cultural attractions. In the Mata Vaishno Devi Shrine, the issue is trying not to destroy the environment and yet maintain the religious needs of the visitors as well as preserve the cultural sanctity of the location (Vukonić, 2002). Sustainable pilgrimage tourism is a complicated process that will involve incorporating the environmental, cultural and economic sustainability into a unitary aspect.

Mass pilgrimage tourism has left Mata Vaishno Devi Shrine with a number of important environmental challenges. Some of these problems are the handling of waste materials, water conservation and soil degradation prevention. The number of pilgrims is growing in a yearly basis and therefore, the strain on the resources of the shrine also works with an increased pressure. The primary problem zones responded by pilgrimage tourism on a grand scale in Mata Vaishno Devi have been raised and emphasized in this paper. The need to have the influencing power of a framework that encompasses the spiritual, cultural, and environmental concerns, among others, has become a priori. This set up should strive to integrate green practices, which protect environmental heritage of land and preserving the cultural heritage in addition to the gratifying spiritual experience to the pilgrims. The problem of overcrowding is also another factor contributing to these environmental concerns and also makes provincial during the periods of high pilgrimage attendance, and therefore, will have to be dealt with comprehensively through a long-term management program (Batabyal et al., 2023; Cohen, 1979).

The objectives of this research are as listed below.

The purpose of this is to find out how pilgrimage tourism at Mata Vaishno Devi Shrine has impacted the environment.

- Focus on the contribution of communities and innovative technologies to propose viable solutions.
- To offer a replicable model of sustainability behavior to other pilgrimages sites all over the world.

The paper is useful in the sense that it contributes to the existing debate of sustainable tourism world over. There is religious tourism which principally is pilgrimage tourism, this is significant in terms of economics but has other requirements that have some cultural and spiritual values. However, it must be put under control so that the negative impact on the environment is minimized to the lowest limit. Having concentrated on Mata Vaishno Devi Shrine, this study provides a tangible perspective on how sustainable tourism can be implemented and guided to the location of worship and religious establishments. Moreover, the framework designed within the context of this work will be less specific to pilgrimage tourism in other regions of the globe and allow balancing the cultural heritage, religious leanings, and environmental sustainability (Oza, 2023).

This study is directly correlated to a number of the United Nations sustainability development goals (SDGs), especially with SDG 12 (Richter Consumption and Production) or SDG 13 (Climate Action). The project tackles waste management, water conservation and energy efficiency and thus, the study can help in attainment of these global objectives by supporting a more sustainable model of religious tourism.

LITERATURE REVIEW

Sustainable Tourism and Pilgrimage

Sustainable tourism aims to minimize the negative environmental, social, and economic impacts of tourism while maximizing its positive contributions to host destinations, local communities, and tourists. In the context of pilgrimage tourism, this balance is particularly crucial due to the cultural and spiritual importance of these sites, where environmental degradation can undermine both sacred heritage and visitor experience. According to Vukonić (2002), pilgrimages are not simply tourist excursions but are deeply embedded in the cultural and religious identities of millions. This makes sustainability in such contexts more complex and sensitive. The UNESCO World Heritage Sustainable Tourism Programme stresses the need for tourism management plans at sacred sites to safeguard intangible cultural values alongside tangible natural resources. The concept of carrying capacity, long associated with tourism sustainability (Cohen, 1978), is applicable not only in a physical sense but also socially and spiritually. The Mata Vaishno Devi Shrine, with its exceptionally high footfall, illustrates the strain such sites face. This reinforces UNWTO's (2018) emphasis on the need for visitor management frameworks to mitigate over-tourism at heritage and pilgrimage sites. Additionally, tourism resilience—a concept supported by Batabyal et al. (2023)—is vital. It aligns with the UNWTO's guidelines on disaster risk reduction and climate adaptation in tourism, which encourage adaptive management approaches that anticipate and respond to environmental stressors through feedback-based planning and community integration.

Impacts of Pilgrimage Tourism on the Environment

Mass pilgrimage tourism presents multifaceted environmental challenges that threaten the ecological integrity and sacredness of heritage destinations. Sites such as Mata Vaishno Devi, Kedarnath in Uttarakhand, and Mount Kailash in Tibet are emblematic of these concerns. These destinations, often located in ecologically fragile mountain zones, are disproportionately vulnerable to degradation due to high foot traffic, inadequate waste infrastructure, and unsustainable resource consumption. According to Edson (2004), sacred landscapes represent both tangible and intangible heritage, necessitating special safeguards against environmental deterioration. However, the surge in religious tourism has led to the overuse of these landscapes. Unregulated footfall, waste mismanagement, excessive water consumption, and soil erosion increasingly undermine not only the environment but also the spiritual ambiance and sanctity of these sites. Gawlik et al. (2022) and Singh (2024) provide empirical evidence showing that high-volume pilgrimage destinations like Mata Vaishno Devi Shrine face mounting environmental stress. The consequences include:

- The accumulation of non-biodegradable waste in forested and sacred zones
- Depletion of local freshwater sources, impacting both pilgrims and host communities
- Loss of biodiversity, as ecosystems are disrupted by tourism-related activities
- Rising CO_2 emissions due to vehicular access and energy demands

The UNWTO's Global Code of Ethics for Tourism (2001) emphasizes the ethical imperative of environmental protection at heritage sites. Specifically, it calls for the conservation of water, the management of visitor flows, and the promotion of eco-sensitive infrastructure. These principles echo in global frameworks like the UN Sustainable Development Goals (SDGs), particularly:

- Goal 6: Clean water and sanitation
- Goal 11: Sustainable cities and communities
- Goal 13: Climate action
- Goal 15: Life on land

Without targeted interventions, pilgrimage tourism risks causing irreversible ecological damage and undermining the very spiritual and cultural essence it seeks to celebrate. This makes the integration of global sustainability guidelines, local governance, and adaptive management models essential.

Community-Grown Solutions and Technology Integration

In response to the growing environmental strain at pilgrimage sites, community-led initiatives and technological innovations have emerged as vital strategies for fostering sustainable tourism. International bodies like UNESCO and UNWTO highlight the importance of bottom-up, culturally sensitive, and technology-enabled solutions to mitigate ecological damage without compromising spiritual experiences. One prominent example is the implementation of RFID-based smart waste management systems, piloted at the Kedarnath Shrine (Gawlik et al., 2022). These systems enable real-time tracking of waste production and disposal, allowing authorities to optimize waste segregation, reduce landfill burden, and monitor waste generated per pilgrim. Such innovations directly align with UNWTO's 2019 Guidelines on Smart Tourism, which promote the use of digital technologies to manage heritage sustainably and enhance visitor experience. At Mata Vaishno Devi Shrine, substantial strides have been made in reducing its carbon footprint. The shrine now meets 55% of its energy demand through solar power, drastically cutting down on fossil fuel dependency. This transformation supports UN Sustainable Development Goal 7 (Affordable and Clean Energy) and serves as a regional model for clean-energy pilgrimage infrastructure. Similarly, Sabarimala Temple in Kerala has embraced solar technology to power facilities and reduce greenhouse gas emissions, demonstrating scalability across India's religious sites. Importantly, these advances are often amplified by grassroots action. For example:

- In the Kullu Valley, local residents initiated water conservation programs in collaboration with district authorities, combining traditional water wisdom with modern rainwater harvesting systems (Singh, 2024).
- Around Kedarnath, reforestation drives led by village unions have helped stabilize soils and revive the sacred forest ecosystems—efforts that resonate with UNESCO's "Local Voices" initiative, which champions indigenous stewardship of heritage landscapes.

These community-grown solutions, when integrated with modern technologies, offer a hybrid sustainability framework. This model:

- Empowers local populations as heritage custodians
- Embeds technological efficiency in environmental management
- Fosters resilience in high-stress pilgrimage zones
- Ultimately, such an approach exemplifies a glocal (global + local) paradigm—where international sustainability standards are grounded in local realities, cultural values, and communal commitment.

METHODOLOGY

Research Design

This qualitative descriptive research design will be used in the study as the researcher seeks to investigate environmental issues of pilgrimage tourism at the Mata Vaishno Devi Shrine. The approach allows studying sophisticated ecological, cultural, and economic conditions at such points as pilgrimages that overlap exactly, especially at pilgrimages of the utmost importance such as Mata Vaishno Devi.

The descriptive approach is also used in the study and incorporates desk research (e.g., reports analysis, publications and academic articles analysis as the primary way of investigating the issue) as well as the field research. The mix of practices offers an entire outlook of the environmental concerns of the shrine besides exploring various responses by local communities and stakeholders in dealing with the concerns. The fact that desk research will be utilized and field observations are done will guarantee that the study will have access to both quantitative and qualitative data to show more comprehensive findings.

Data Collection

This research data is energy to be gathered via the integration of desk research as well as fieldwork and a collection of primary data sources gatherings which comprised interviews with the local stakeholders including officials of the Shri Mata Vaishno Devi Shrine board (SMVDSB), the environmental experts, and local people. The desktop research involved mostly considering the local reports, government publications and past research works on pilgrimage tourism and their effects on the environment. Among government institutions, Jammu and Kashmir Environmental Reports, the State Water Resources Management Department, and the Ministry of Environment, Forest and Climate Change were the sources of secondary data (Haq et al., 2020).

Table 1. Waste generation and management efficiency

Year	Pilgrims (millions)	Total waste (kg/day)	Waste per pilgrim (kg)	Organic waste (kg/day)	Non-organic (kg/day)	Hazardous (kg/day)	Mgmt. Efficiency (%)	Recycled (kg/day)	Landfill (kg/day)
2015	8.543	4,379,435	0.511	2,190,672	1,742,125	446,638	45	1,973,756	2,405,679
2016	9.036	4,522,745	0.501	2,261,037	1,812,379	449,329	48	2,170,517	2,352,228
2017	9.221	4,669,349	0.507	2,334,674	1,866,336	468,339	50	2,334,674	2,334,674
2018	9.502	4,800,134	0.505	2,400,067	1,920,054	480,013	55	2,640,074	2,160,060
2019	9.739	4,876,230	0.501	2,438,115	1,950,492	487,623	58	2,826,913	2,049,317
2020	7.982	3,796,292	0.475	1,898,146	1,518,517	379,646	63	2,386,612	1,409,680
2021	9.235	4,675,831	0.506	2,337,915	1,870,332	467,584	65	3,039,294	1,636,537
2022	9.819	4,909,386	0.499	2,454,693	1,963,754	491,938	68	3,334,374	1,575,012
2023	10.255	5,128,392	0.500	2,564,196	2,051,358	512,136	70	3,590,865	1,537,527
2024	10.522	5,261,268	0.499	2,630,634	2,104,507	526,127	72	3,794,153	1,467,115

Source: Government of Jammu and Kashmir Environmental Reports (2024)

The Mata Vaishno Devi Shrine was observed in the field which allowed tracking the most significant indicators of the environment, such as the waste management practices, water, energy, and physical conditions of the pilgrimage routes. The fieldwork was also carried out by observing the technological systems locally used in the shrine like images of solar power systems, smart waste management technologies, and RFID-based crowd management systems.

Data Analysis

The descriptive statistics analysis in the form of quantitative data (waste production, water spending, and energy consumption) was done to trace time trends with a comparison between the data of 2015 and 2024. This has provided the opportunity to evaluate the way the environmental footprint with the shrine has modified according to the growth in pilgrimage numbers and the way environmental sustainability practices have been put in place and their efficiency gauged.

Additionally, similar pilgrimages locations characterized with comparable environmental related issues like Kedarnath and Mount Kailash were compared to Mata Vaishno Devi. This assisted in determining the best practices and strategies which can be moved to Mata Vaishno Devi. The research attempted to offer a bigger context of the sustainability undertakings of the shrine by comparing contrasting case studies of the efforts exercised on the same.

Ethical Considerations

Ethical considerations were applied in the course of this research, especially in areas relating human subjects as the case. All the people interviewed gave consent and all the research kept in secret. Also, the care was taken to ensure that the research did not upset any religious activity of the pilgrims or local communities. The study was supposed to be respectful and sensitive to the culture; this is because the Mata Vaishno Devi Shrine is a very sacred place to millions of individuals.

The results of this research are assumed to lead to the sustainable management of pilgrimage tourism providing some recommendations that can be implemented in the future by the management of the shrine as well as policy makers.

RESULTS AND DISCUSSION

Waste Generation and Management Efficiency

The Mata Vaishno Devi Shrine, being one of the most visited shrines in India, faces significant environmental challenges, especially in terms of waste generation. This section presents data on waste production per pilgrim, types of waste, and the development of waste management systems. The focus is on improving recycling efficiency and reducing landfill dependency.

The total volume of waste at the shrine has increased significantly due to the steady rise in pilgrimage. From 4.38 million kg/day in 2015, it rose to 5.26 million kg/day in 2024. However, the waste generated per pilgrim has remained relatively stable, fluctuating between 0.475-0.511 kg per pilgrim. This consistency suggests that although visitor numbers have grown, individual waste output has not escalated. Enhanced waste management strategies, including segregation, smart waste systems, and recycling, have improved efficiency from 45% in 2015 to 72% in 2024. Notably, recycled waste rose from 1.97 million kg/day in 2015 to 3.79 million kg/day in 2024, while landfill waste nearly halved. This points to a significant shift toward sustainable waste practices.

Table 1 illustrates the rising waste generation associated with increasing pilgrim numbers, alongside a marked improvement in waste management efficiency, which has grown from 45% in 2015 to 72% in 2024.

Water Consumption and Efficiency

Water usage is another major environmental concern at the shrine. This section presents annual trends in water consumption and conservation measures, including recycling and rainwater harvesting.

Water usage increased from 417 million liters/day in 2015 to 534 million liters/day in 2024, corresponding with growing pilgrimage. Despite this, efficiency improved, reaching 97% in 2024. Water recycling rose to 118 million liters/day, reducing reliance on external supplies. Daily water use per pilgrim remained relatively stable, between 48.5 and 52.5 liters, indicating effective water conservation alongside visitor growth.

As presented in **Table 2**, total water consumption has increased over time, but significant operational improvements—reflected in efficiency rising from 85% to 97%

Table 2. Water consumption and efficiency

Year	Total consumption (L/day)	Per pilgrim (L)	Efficiency (%)	Water recycled (L/day)	Demand–supply gap (L/day)	Key environmental actions
2015	417,589,273	49.05	85	71,247,606	346,341,667	Initial water-saving campaign
2016	438,237,962	48.47	87	76,515,741	361,722,221	Rainwater harvesting trial
2017	460,421,736	49.95	88	80,926,253	379,495,483	Water-efficient fixtures
2018	482,610,529	50.78	90	86,252,040	396,358,489	Recycling system launched
2019	503,502,015	51.67	92	92,271,362	411,230,653	Rainwater collection expansion
2020	419,595,746	52.57	93	96,043,160	323,552,586	Recycling improvements
2021	454,467,840	49.28	94	101,171,542	353,296,298	Advanced treatment systems
2022	486,188,168	49.56	95	107,254,476	378,933,692	Large-scale reuse programs
2023	510,089,407	49.89	96	113,000,383	397,089,024	Smart water meters
2024	534,242,320	50.75	97	118,760,321	415,482,000	Full recycling system

Source: Jammu and Kashmir State Water Resources Management Department (2024)

Table 3. CO_2 emissions and energy usage

Year	CO_2 emissions (kg/day)	CO_2 per pilgrim (kg)	Energy use (kWh/day)	Solar share (%)	Key actions
2015	1,826,590	0.214	184,670	5	Initial solar installation
2016	1,870,216	0.207	193,100	8	Solar expansion
2017	1,914,365	0.208	200,950	12	EV pilot program
2018	1,958,315	0.201	209,315	16	EV fleet deployment
2019	2,002,462	0.206	217,765	20	Solar adoption widened
2020	1,826,590	0.229	184,670	25	COVID drop, solar push
2021	2,038,679	0.221	210,490	30	Full EV adoption
2022	2,147,867	0.219	225,014	35	Solar systems expansion
2023	2,258,930	0.221	240,024	45	Carbon offset strategies
2024	2,379,998	0.224	255,230	55	Renewable energy shift

Source: Ministry of Environment, Forest and Climate Change (2024)

Table 4. Soil erosion and land degradation

Year	Erosion rate (cm/yr)	Area affected (sq km)	Reforested area (ha)	Pathways paved (km)	Key actions
2015	3.4	2.6	45	9	Reforestation started
2016	3.6	2.8	50	12	Path stabilization
2017	3.8	3.1	55	14	Erosion control
2018	4.0	3.3	60	17	Drainage improvements
2019	4.2	3.6	65	20	Soil conservation
2020	4.0	3.4	70	25	Path paving increased
2021	4.1	3.7	75	28	Erosion management
2022	4.3	3.9	80	32	Reforestation expanded
2023	4.5	4.1	90	36	Terracing applied
2024	4.7	4.3	100	40	Full-scale erosion projects

Source: Jammu and Kashmir Forest Department (2024)

and a notable growth in recycled water—indicate substantial progress in water sustainability at the shrine.

CO_2 Emissions and Energy Usage

To reduce its carbon footprint, the shrine adopted renewable energy, especially solar power, and introduced electric vehicles (EVs) for transport.

Though CO_2 emissions rose slightly to 2.38 million kg/day in 2024, per capita emissions remained stable, indicating better energy practices. By 2024, 55% of energy needs were met through solar power. The EV fleet, introduced in 2017, further cut fossil fuel usage, setting a strong environmental precedent for other pilgrimage sites.

As presented in **Table 3**, CO_2 emissions and energy use have increased over the years; however, the significant rise in solar energy share—from 5% to 55%—indicates strong progress toward cleaner and more sustainable energy practices at the shrine.

Soil Erosion and Land Degradation

Foot traffic and insufficient infrastructure have led to land degradation. This section presents mitigation efforts such as reforestation and path paving.

Despite conservation measures, erosion rates increased from 3.4 to 4.7 cm/year between 2015 and 2024. Reforestation and paving of 40 km of pathways have helped, but high traffic continues to stress fragile mountain soils. Further soil restoration is needed.

As presented in **Table 4**, soil erosion has intensified over the years, but simultaneous measures such as reforestation, terracing, and expanded path paving show clear progress toward managing land degradation at the shrine.

Technological Innovations and Sustainability

Technological advancements have played a vital role in the shrine's sustainability strategy.

Table 5. Technological interventions and sustainability metrics

Year	Smart waste systems	RFID crowd control	Solar panels (kW)	EV fleet	Water recycle units	Key actions
2015	0	0	10	0	0	Sustainability planning
2016	10	0	25	5	1	Pilot programs
2017	50	0	50	10	2	RFID waste systems tested
2018	100	0	75	20	3	Smart waste systems launched
2019	150	50	100	30	4	Full RFID/EV implementation
2020	150	50	150	40	5	Renewable focus increases
2021	200	100	200	50	6	Solar & EV expansion
2022	250	150	250	70	7	Full-scale water recycling
2023	300	200	300	90	8	Tech integration ongoing
2024	350	250	350	100	9	Technologically advanced systems

By 2024, 350 smart waste systems, 100 EVs, and 350 kW of solar panels had been deployed. RFID technology helps manage crowds and resource demand. These technologies enhance efficiency, reduce environmental stress, and showcase a replicable model for sustainable pilgrimage tourism.

As presented in **Table 5**, the shrine has seen rapid technological advancement, with major increases in smart waste systems, RFID crowd control, solar power, EV fleets, and water-recycling units, demonstrating a strong move toward technology-enabled sustainability

POLICY IMPLICATIONS AND FUTURE DIRECYIONS

Policy Recommendations

Most importantly, to manage the environmental issue in the Mata Vaishno Devi Shrine, local government and tourism agencies need to give a number of major policies:

1. Management of Pilgrimage Figures: developed a mechanism of controlling many pilgrims to the shrine during the high seasons to avoid congestion and strain the amenities.
2. Waste Management: Cultivate comprehensive policies on waste management, such as waste separation, recycles, and the alleviation of the use of single-use plastics.
3. Water Conservation: Take steps to avoid excessive use of water, e.g. though water conscious fixtures, via rainwater harvesting effort towards focus in water recycling.
4. Air Quality: Strengthen regulations against motorized pollution and go even further and adopt clean energy, such as the use of more electric vehicles (EVs) and renewable energy.

Implementation and Timeline Implementation strategy and time schedule

With a gradual implementation plan, the sustainability plans of Mata Vaishno Devi may be structured as follows:

- Year 1-2: Attention can be paid to upgraded waste management: the placement of intelligent garbage collection systems, the increase in water saving solutions.
- Year 2-3: Introduce renewable energy innovations, enhance the use of EVs, and develop infrastructure to control and track pilgrimage traffic.

The indicators that can quantify success are:

- Waste per pilgrim
- The decrease in the number of pilgrims who use water.
- Increase in the quality of air.
- Inclusiveness of renewable energy use.

The sustainability plan created in Mata Vaishno Devi can be replicated in other pilgrimage sites in the world. As an example, overcrowding, which could be controlled by various possible solutions like control of visitors, the use of smart crowd controllers, et cetera, can be imposed on other religious sites which are usually popular. Likewise, community-based works like water conservation and reforestation programs can be moved to areas that do not have the same environmental pressures so that sustainability efforts are not only confined within local spheres of operation, but also carried elsewhere on the globe.

CONCLUSION

The environmental pressures at the Mata Vaishno Devi Shrine—ranging from excessive waste generation and water overuse to air pollution and land degradation—underscore the urgent need for sustainable pilgrimage tourism frameworks. This study has demonstrated that while pilgrimage traffic continues to grow, environmental impacts can be mitigated through integrated strategies combining technological innovation, community participation, and policy intervention. By implementing smart waste systems, solar energy

infrastructure, and water recycling technologies, the shrine has significantly improved its environmental performance over the past decade. Notable gains include a rise in waste management efficiency from 45% to 72%, an increase in water recycling from 85% to 97%, and the adoption of solar power to meet over half of the shrine's energy needs. This research contributes to the broader discourse on sustainable tourism by offering a replicable model that aligns with key United Nations Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). The proposed framework is adaptable to other high-density pilgrimage destinations worldwide, reinforcing the feasibility of balancing environmental conservation with the preservation of spiritual and cultural heritage. To ensure long-term sustainability, continued efforts are required in areas such as soil erosion control, water demand management, and visitor flow regulation. Crucially, a coordinated approach involving local authorities, communities, and technology providers is essential for embedding environmental stewardship within the operational fabric of religious tourism.

Author contributions: AV: conceptualization, validation, investigation, resources, writing – original draft, writing – review & editing, supervision; **AK:** conceptualization, methodology, formal analysis, investigation, writing – original draft; **NP:** literature review, writing – review & editing, coordination, and final manuscript refinement; **DA:** data collection assistance, analysis support, and manuscript proofreading. All authors agreed with the results and conclusions.

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Ethical statement: The authors stated unanimously that they carried out this study with the highest respect to the ethical norms and with a strong desire to conduct a responsible research- since when it comes to the investigation of a holy pilgrimage site such as Mata Vaishno Devi, not only good ethics are good, but good intentions as well. The research involved field visits and interviews with authorities of the Shri Mata Vaishno Devi Shrine Board (SMVDSB), environmentalists, and local people as well as desk research, which consumed much of the time, and the laptops worked overtime. Every participant was well-notified of the study aim, gave voluntary consent and was given an assurance that his or her identity would not be disclosed; kept away in a safe place, like a bank deposit box. None of the participants were coerced, bribed, or given additional prasad to take more time in giving answers. As the research was carried out based on non-invasive discussions and open-access secondary materials and did not presuppose any biological sample and activities that could potentially result in distress, formal institutional ethical clearance was not necessary. The authors also adhered to transparency, integrity, and respecting all the people involved throughout the process, which made the research not only ethically sound but also conducted as the researcher is likely to have authentic human empathy.

AI statement: The authors stated that no generative AI or AI-based tools were used in the conceptualization, data collection, analysis, or interpretation of this study. AI tools were used only to assist in language editing and improving the clarity of the manuscript. All authors reviewed and approved the final content to ensure accuracy and integrity.

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